Combined Heat & Power
The Concept

Presentation to
The Distributed Energy Road Show
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Presentation Outline

- **CHP: The Concept**
- **CHP: The Technologies**
- **CHP: The Economics**
- **CHP Assistance in the Midwest**

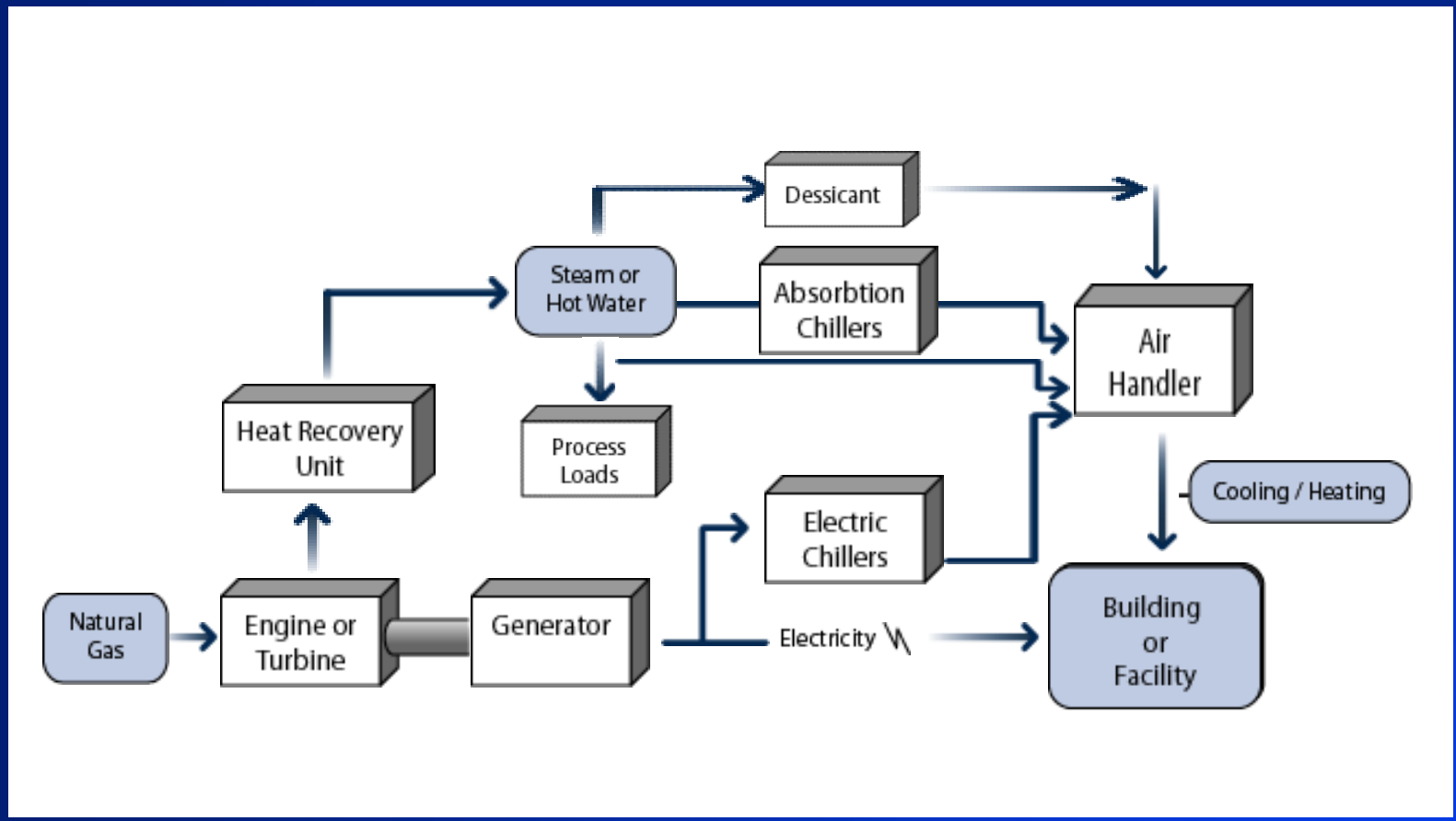
What is CHP?

- Integrated System
- Located At or Near a Building/Facility
- Provides a Portion of the Electrical Load
- Utilizes the Thermal Energy
  - Cooling
  - Heating
  - Dehumidification
  - Process Heat

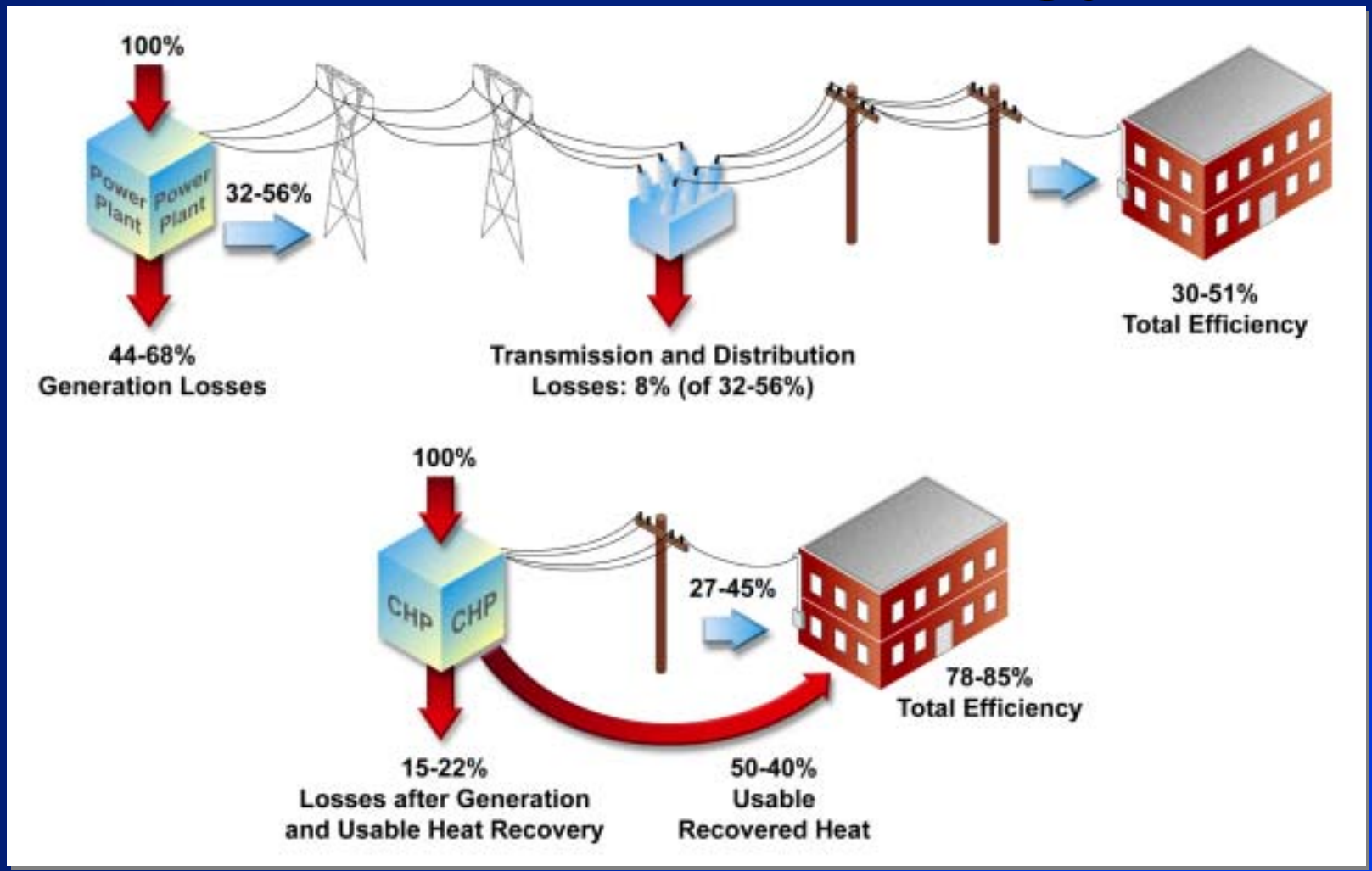
CHP System Sizes *(Terminology)*

System Designation	Size Range	Comments
Mega	50 to 100+ MWe	• Very Large Industrial • Usually Multiple Smaller Units • Custom Engineered Systems
Large	10's of MWe	• Industrial & Large Commercial • Usually Multiple Smaller Units • Custom Engineered Systems
Mid	10's of kWe to Several MWe	• Commercial & Light Industrial • Single to Multiple Units • Potential Packaged Units
Micro	<60 kWe	• Small Commercial & Residential • Appliance Like

Typical Commercial CHP System



How CHP Saves Energy



Benefits of CHP

High Efficiency, On-Site Generation Means …

- Improved Reliability
- Lower Energy Costs
- Better Power Quality
- Provides Standby Power
- Lower Emissions (including CO2)
- Support Grid Infrastructure
  - Fewer T&D Constraints
  - Defer Costly Grid Upgrades
  - Price Stability
- Facilitates Deployment of New Clean Energy Technologies
- Enhances Competition

Top 10 Impediments to CHP

6. **Assessing CHP Value (Beyond Energy Cost Reduction)**
   Hard to Identify, Quantify, and Allocate Among Parties
7. **Stakeholder Apathy**
   Lack of Incentive for Facility Managers and Engineering Firms to Try Something Different
8. **High First Cost**
   Discourages Investment Despite Life Cycle Benefits
9. **Electric Restructuring**
   Creates Uncertainty and a "Wait and See" Attitude
10. **Too Few Case Studies**
    Inconsistent, Hard to Find, and Often Incomplete in Financial Details

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Top 10 Impediments to CHP

1. **Interconnection**
   Inconsistent Standards, Complex Process, Network Issues and Unpredictable or High Costs
2. **Utility Tariffs**
   Standby Charges and General Rate Design
3. **Electric Utility Response**
   Often Times Ambivalent at Best, Hostile at Worse
4. **Lack of Familiarity**
   With CHP Technologies, Concepts, and Environmental Benefits
5. **Permitting Process**
   Sometimes Long, Cumbersome, and Costly

Key Factors for CHP Attractiveness

- **Coincident Needs for Power & Thermal Energy**
- **Cost of Buying Electric Power from the Grid Relative to the Cost of Natural Gas**

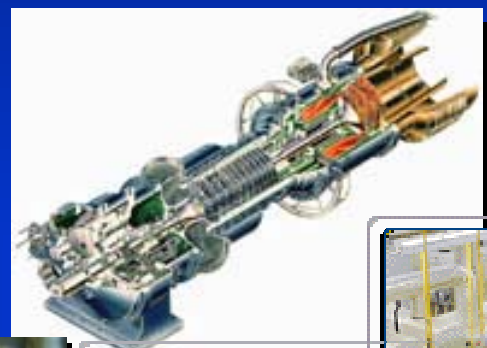
  a.k.a "Spark Spread"
- **Installed Cost Differential Between a Conventional and a CHP System**

Candidate Applications for CHP

- Hospitals
- Universities
- Industrial Facilities
- Institutional Buildings
- High Rise Hotels
- Fitness Centers
- High Schools
- Office Buildings
- High Security Loads
- High Reliability Loads
  - Data Centers
  - Telephone Switching

Reliable CHP Technologies

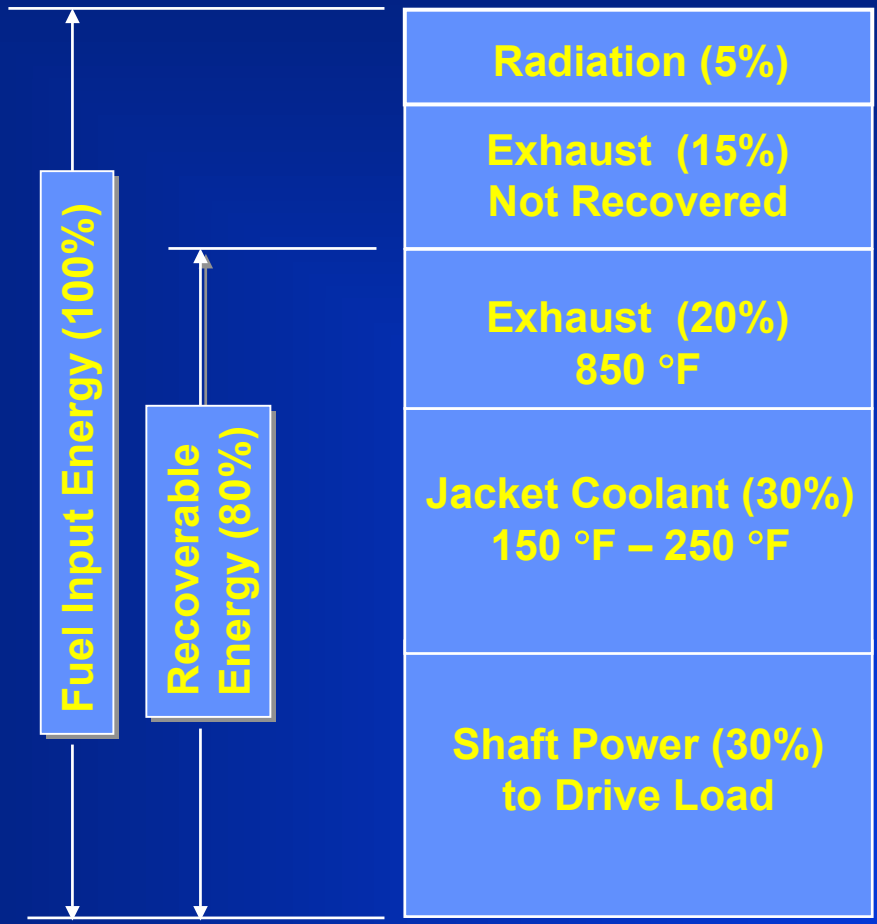
- Electric Generation Equipment
  - Reciprocating Engines
  - Turbines / Microturbines / Fuel Cells



Reciprocating Engines

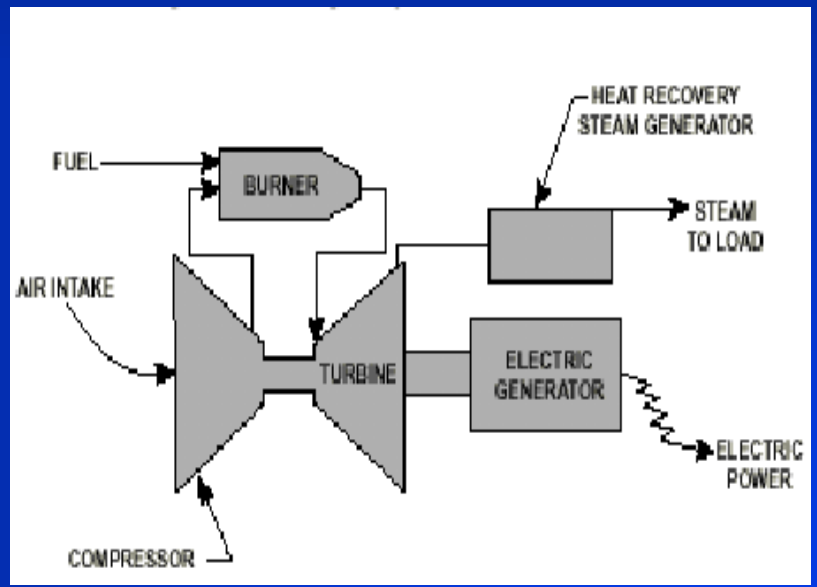
- Fastest Selling, Least Expensive CHP Prime Mover Technology Below 5 MW
- Typical Power Range: 5 kW - 10 MW
- Efficiency Range: ≈ 25% - 40% LHV
- Part Load Operation: OK
- Type of Engines:
  - Spark Ignited --- Natural Gas / Gasoline / Biogas
  - Compression Ignition --- Diesel
  - Dual Fuel –Diesel Pilot

Reciprocating Engine - Heat Balance



Gas / Combustion Turbines
(How Do They Work)

- Burns Gas or Liquid Fuel at High Pressure
- Expand Hot Products of Combustion Through Turbine Blades Mounted On A Shaft
- Produces A High Speed Rotary Motion
- Drives An Electric Generator, Producing Electric Power
- High Temperature Exhaust For Heat Recovery



Gas / Combustion Turbines

- Available Size Range: 500 kW - Hundreds of MW
- Typical for CHP: Several MWs to Tens of MWs
- Efficiency Range: 25% to 40% LHV (Simple Cycle)
- Typically 3 Configurations:
  - Simple Cycle (Most Common in CHP)
  - Recuperated
  - Combined Cycle
- Thermal (Recoverable) Energy:
  - Exhaust Gas @ 900 °F to 1100 °F
  - Excellent for High Grade Steam @ 150 psig and Higher

Microturbines

- Small Turbines with Recuperation
- Capacity Range: 25 kW to 400 kW
- Efficiency Range: 25% to 30% LHV
- Recoverable Heat: Gas Exhaust @ Approximately 500 °F

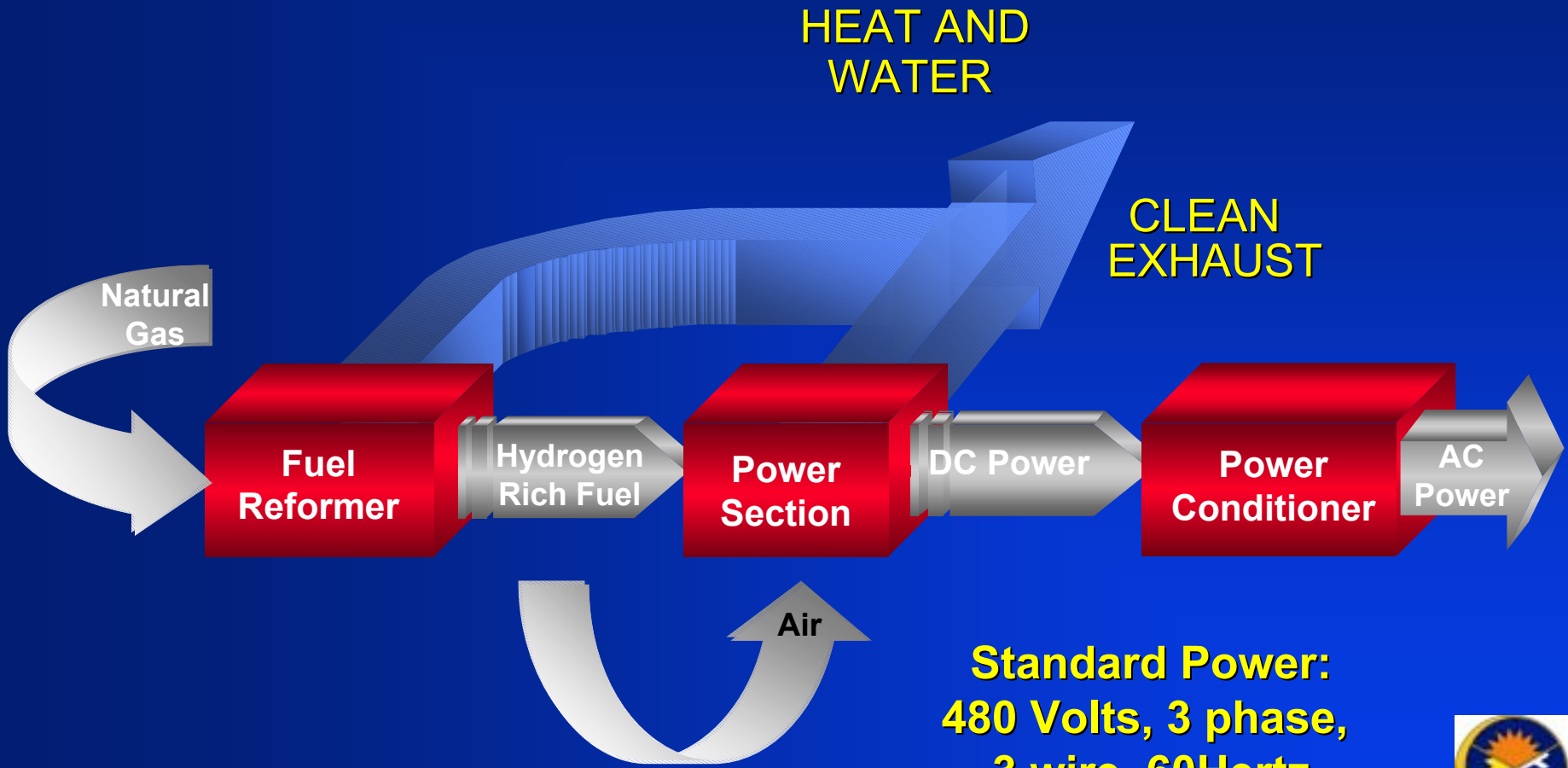
Microturbines

- **Advantages:**
  - **Compact Size**
  - **Low Emissions (< 0.49 lbs/MWh or 9 ppm)**
  - **Fuel Flexibility**
  - **Modular**
  - **Lower Maintenance**
    - » **No Oil Change** *(Applicable to Some Units)*
    - » **No Spark Plug Change**
    - » **No Valves**
    - » **Small # of Moving Parts**
  - **Quicker Start**

Microturbines

- Disadvantages:
  - Early Market Price Uncertainty
  - Moderate Conversion Efficiencies
  - Poor Part Load Operation
  - Requires High Pressure Gas (Up to 80 psig) or Gas Compressor
  - Efficiency and Output Sensitive to Ambient Temperature

Fuel Cell System Scheme



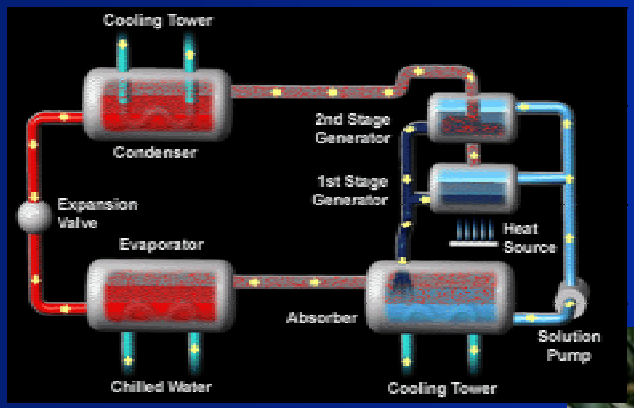
Standard Power:
480 Volts, 3 phase,
3 wire, 60Hertz

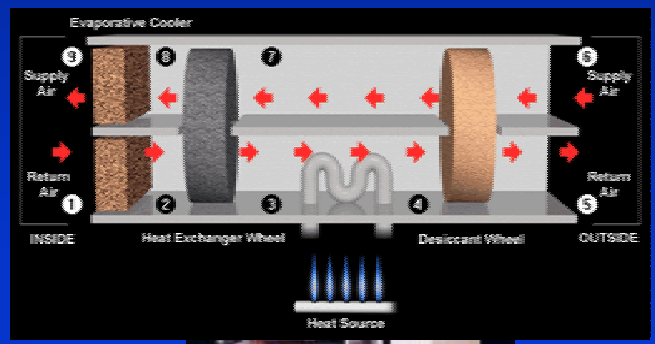
Fuel Cells
(Rules-of-Thumb)

Fuel Cell Type	Availability	Efficiency	Operating Temperature	Heat Utilization
Phosphoric Acid (PAFC)	Commercial >$3,500/kW	38 – 45%	480 °F	Hot Water
Solid Oxide (SOFC)	Demonstration	40 – 45%	1,800 °F	High Pressure Steam
Molten Carbonate (MCFC)	Demonstration	50 – 60%	1,200 °F	Medium to High Pressure Steam
Proton Exchange Membrane (PEM)	Demonstration	33 –45%	175°F	Hot Water

Reliable CHP Technologies

- Thermally Activated Technologies
  - Absorption Chillers
  - Desiccant Dehumidification





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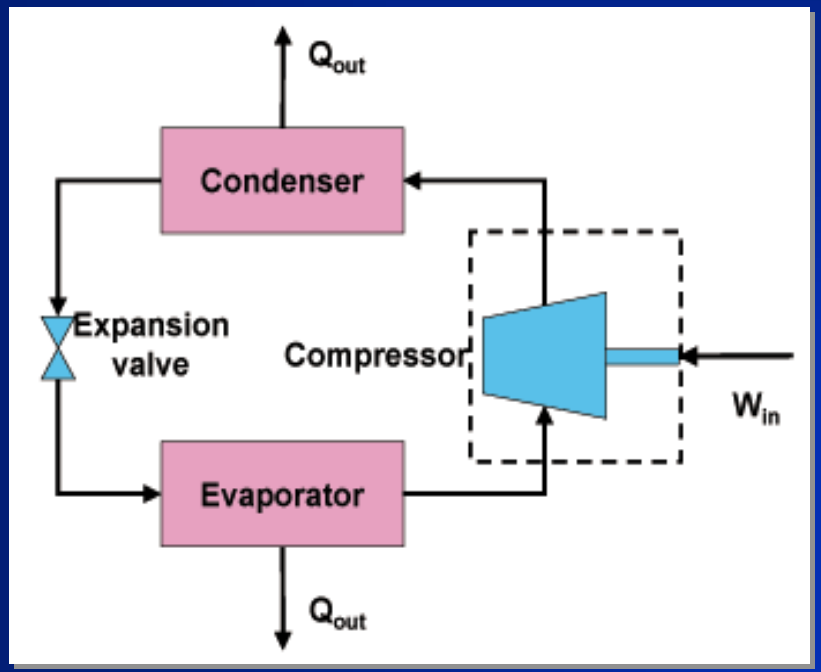
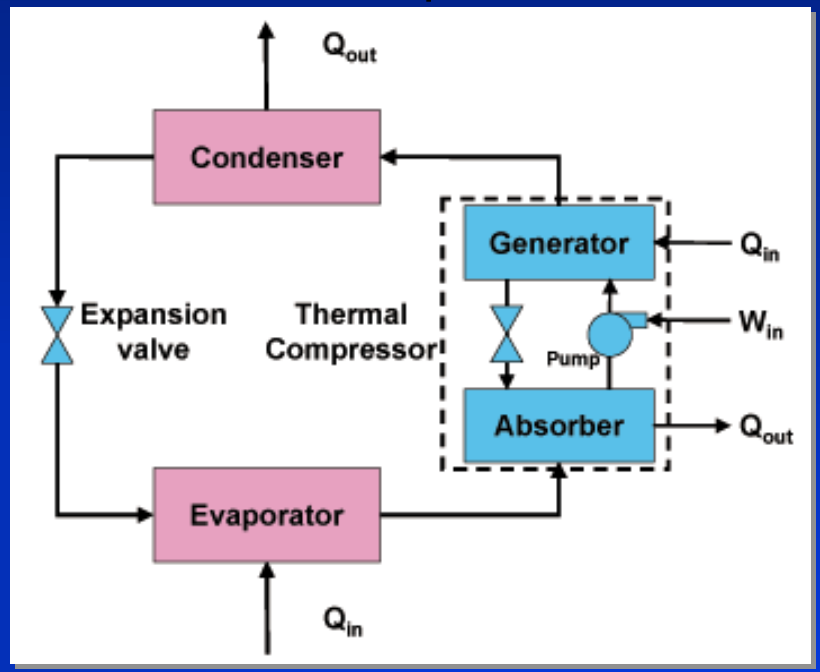
Chiller Types

Mechanical Chiller



- Electric Motors
- Reciprocating Engines
- Combustion Turbines
- Steam Turbine

Thermal Absorption Chiller



- Direct Combustion
- Waste Heat Fired
  - Steam
  - Hot Water
  - Hot Exhaust Gas

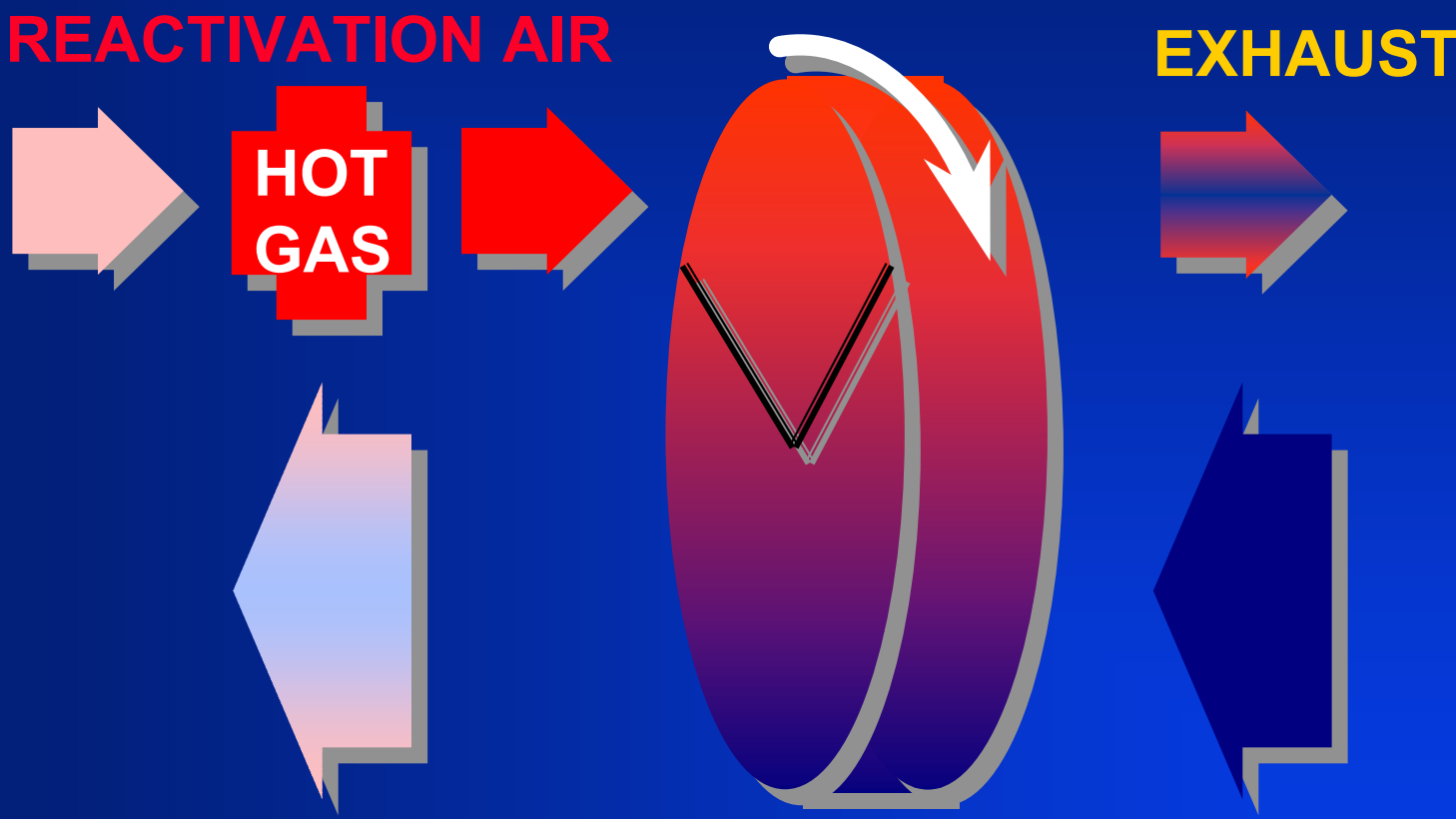
Thermally Activated Chiller Solution Types

- Solutions Generally Used Are:
  - Water as the Refrigerant and Lithium Bromide as the Absorbent
  - Ammonia as the Refrigerant and Water as the Absorbent
  - Heat Recovery Applications Generally Use:
    - » Single Effect
    - » Water/Lithium Bromide

Thermally Activated Technologies (Desiccant Dehumidification)

- Removes Moisture From Air (Latent Load)
  - Reduces the Demand on the Cooling System to Reduce Humidity
  - Improves Indoor Air Quality
    - » Reducing Mold Growth
    - » Reducing "Over Cooling"
    - » Allowing Higher Make-Up Air Rates for the Same Energy Usage
- Two Types Available:
  - Solid Desiccants
  - Liquid Desiccants (Kills Bacteria & Viruses)

Desiccant Dehumidification Active Desiccant Wheels



Other Components

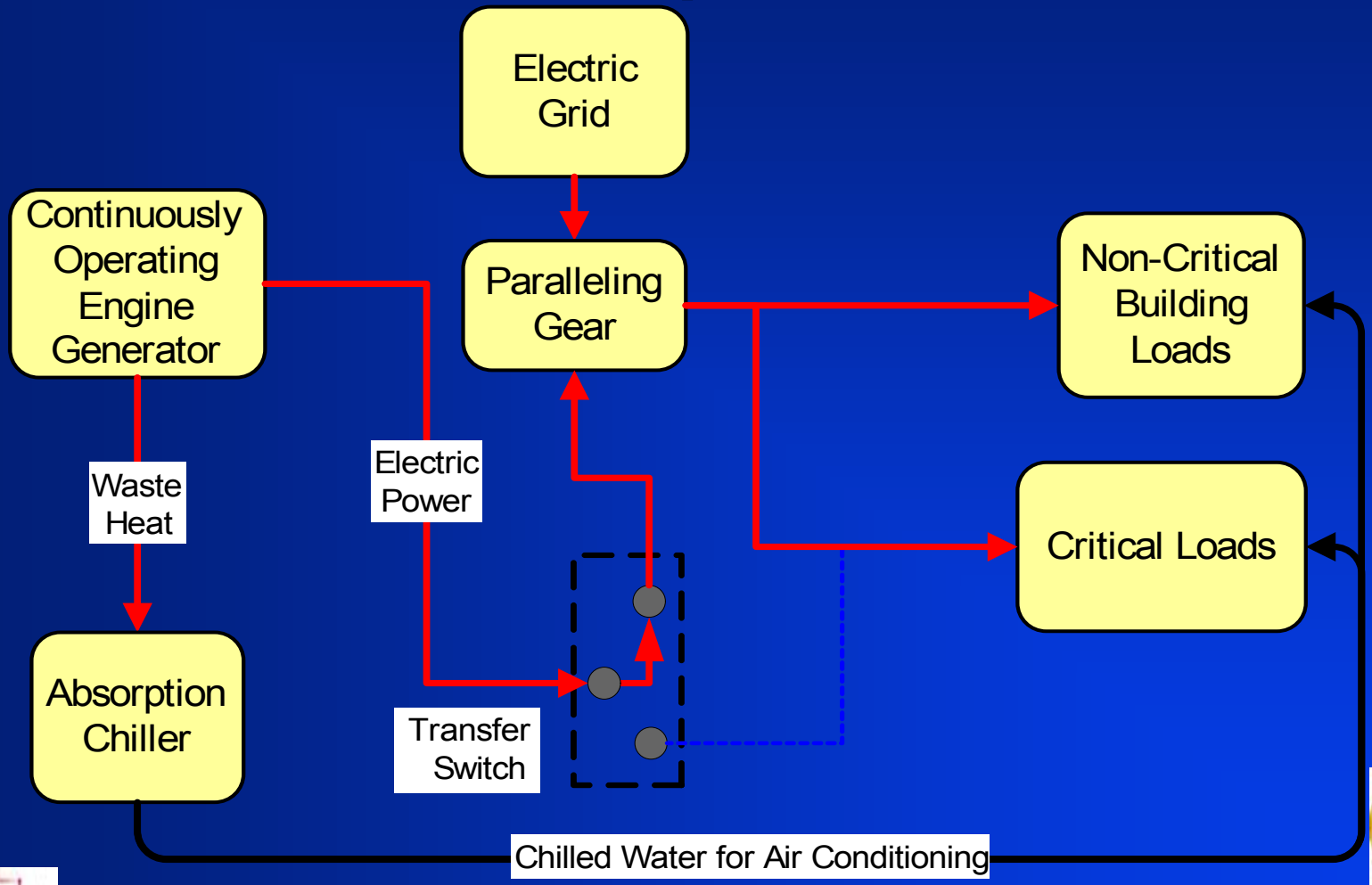
- Grid Interconnect:
  - Isolation Switch
  - Switchgear
  - Protection Relays
    - » Voltage
    - » Current
    - » Frequency
    - » Power
  - Synchronizing Equipment
- Installation:
  - Equipment Footprint
  - Floor Loading
  - Proximity To HVAC Equipment
  - Number of Electrical Feeds

CHP Can Supply Power Back-Up

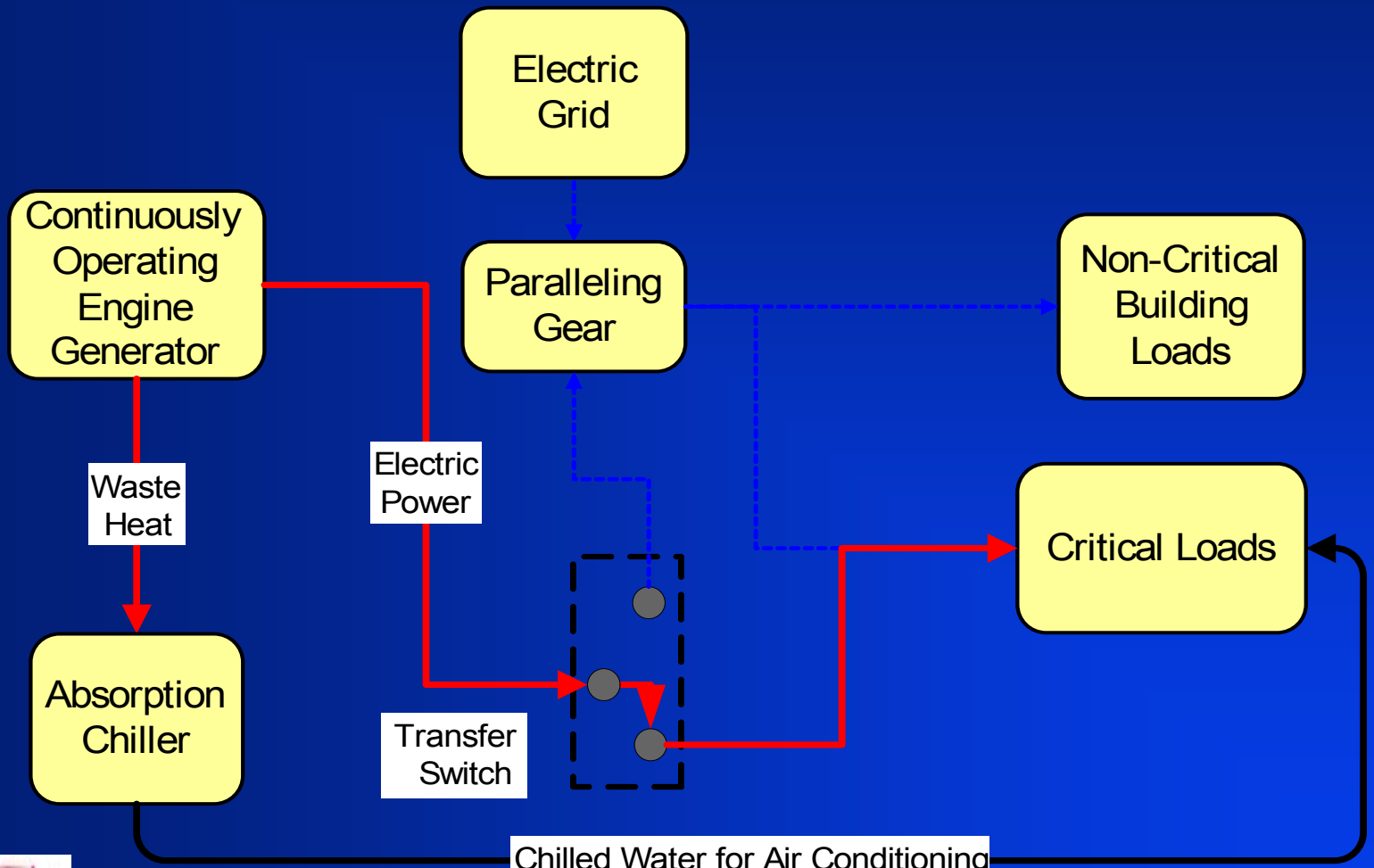
- **Redirect Generator Output to Emergency Circuits During a Power Outage**
- **CHP Turns an OVERHEAD EXPENSE (Back-Up Generators) into a PROFITABLE ASSET**

How Can CHP Serve As Back-Up Power

Normal Operation



How Can CHP Serve As Back-UP Power
During Power Outage



CHP -- Economics

- **Most CHP Systems Operate During Peak Demand or Peak Energy Periods**
- **Most CHP Systems Can Produce Power for Approximately 5 to 6 cents per kWh**
- **A Typical 1000 kW CHP System Can Save From $135k to $200k Annually**
- **A 1000 kW CHP System Is Typically Installed for $900 to $1200 per kW**

CHP -- Economics

- **Most CHP Systems Have a Payback of 4 to 7 Years But …**
  - **Paybacks Can Be Reduced If Standby Generator Sets Were Going To Be Installed**
- **Factors That Impact CHP Installations:**
  - **Packaged vs. Site Constructed**
  - **Proximity to Electric Services & Thermal Usage**
  - **Site Modifications – Structure for CHP System**
  - **Electric Interconnect Costs**
  - **Permitting Costs**

CHP Assistance In The Midwest

Midwest CHP Application Center

- **Partnership – UIC/ERC & GTI**
- **Located at the Univ. of Illinois at Chicago**
- **Areas Served: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, Wisconsin**
- **Services:**
  - **Information**
  - **Education**
  - **Technical Assistance**

CHP Is A Triple Win

- **Saves Money --- End User**
- **Energy Efficiency and Cleaner Environment --- Government**
- **Provides Business Opportunity --- Industry**

For Further Information

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